GPS Position Latency Determination and Ground Speed Calibration for the SATLOC AirStar M3

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Variable-Rate Aerial Application – *a reality?*

Introduction

What is variable-rate aerial application?

➔ Application rate is adjusted to match the need associated with specific areas of a field.

➔ Requires hardware/software for:

➢ Detecting spatial position

➢ Determining the required application rate for that position from a 'prescription' file

➢ Adjusting the application rate to that value

Introduction

Existing variable-rate aerial application systems have been configured as the combination of a Swath Guidance System and an Automatic Flow Control System.

Most liquid-spray aerial systems that I am aware of use the SATLOC AirStar M3 and the AutoCal II flow controller interfaced to a hydraulically powered chemical pump.

Introduction

Variable-Rate Systems function by:

➔ Determining the current spatial position and ground speed using GPS technology

➔ Querying the 'prescription' file to get the application rate required for that position

➔ Communicating the application rate and ground speed to the flow controller

➔ Computing the required boom-flowrate to achieve the specified application rate

➔ Reading the flow meter and adjusting the chemical pump output appropriately

Objectives

➔ Determine the magnitude of any GPS position latency that might exist

➔ Check the accuracy of the GPS ground speed values

Definition

Position Latency refers to the difference between the GPS position coordinates indicated by the aircraft GPS system and the GPS position coordinates of a reference point on the ground surface when the aircraft is directly over the reference point.

Materials and Procedures

Aircraft GPS position coordinates were collected from the data log of the SATLOC AirStar M3 with WAAS correction installed on an AT402B.

Reference point GPS position coordinates were determined with a Rockwell Military GPS receiver using the Precision Positioning Service (PPS) with military P(Y) code capabilities to enhance position accuracy.

Materials and Procedures

Aircraft position was synchronized with the reference point position through the use of a vertical light beam from the reference point being detected by a photo-detector on the aircraft.

Materials and Procedures
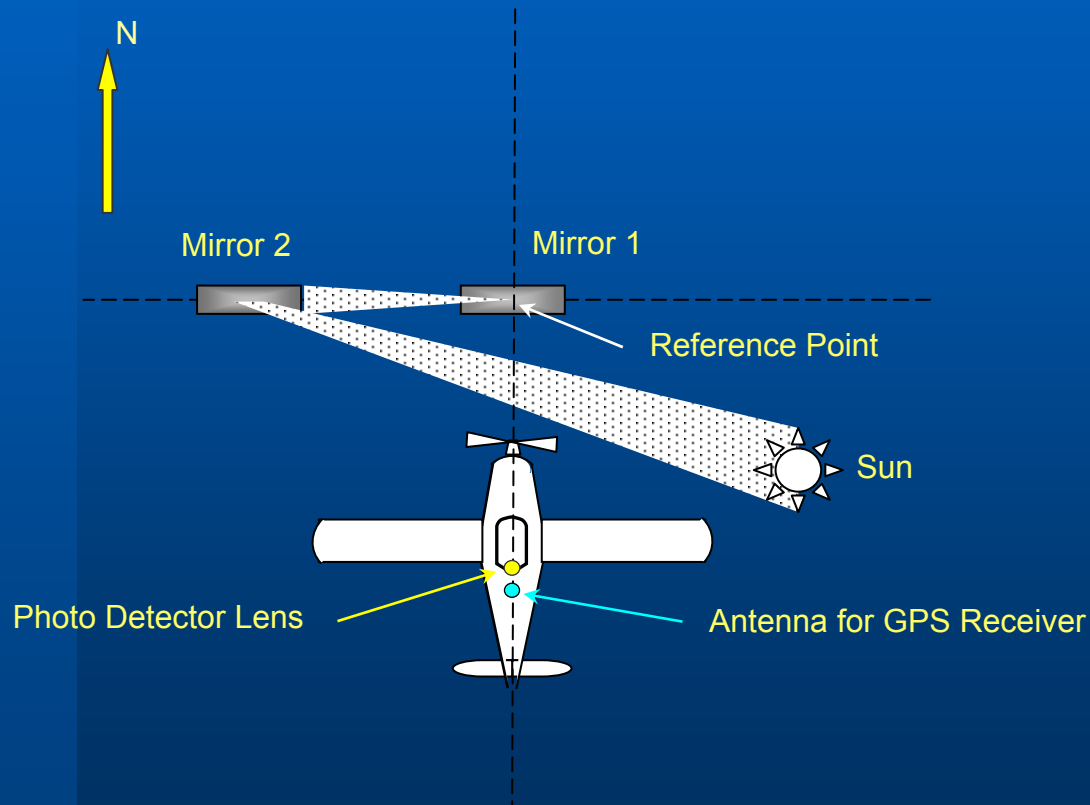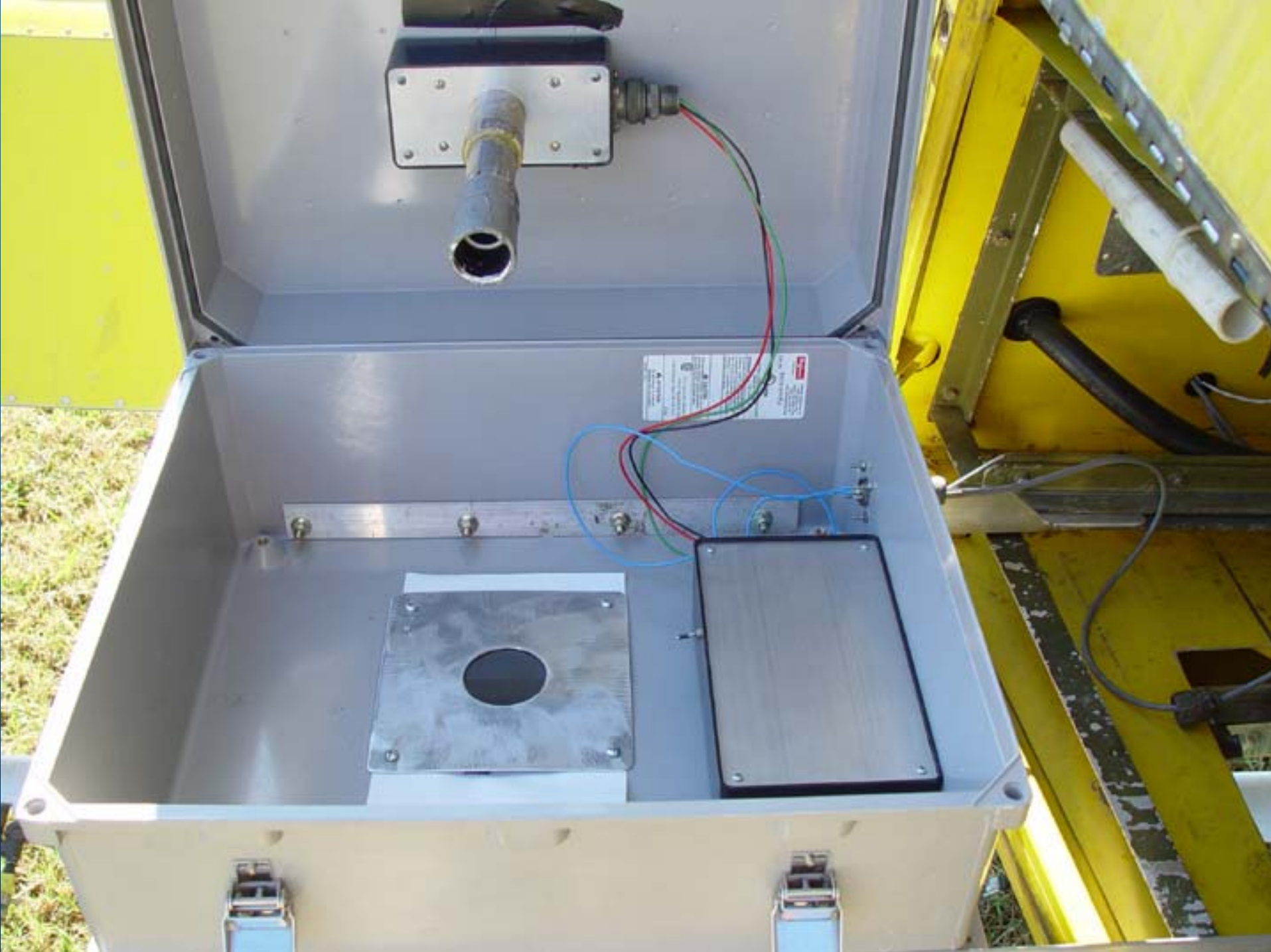
Methods and Materials

GPS ground speed calibration was performed by using two reference stations and flying over them in a straight line

➔ The first station simulated the start of spraying

➔ The second station simulated the end of spraying

Methods and Materials

- GPS ground speed was logged at one second intervals

- Average GPS ground speed was computed by dividing the area under the 'speed vs. time' curve (found by numerical integration) by the time required to traverse the distance.

- Calibration standard was:

    Travel Distance / Elapsed Time

Methods and Materials

- GPS coordinate values were logged by the SATLOC system as decimal degrees in the WGS84 datum

- Conversion to Cartesian coordinates were made using zone 15 of the UTM Projection using PROLAT software (Effective Objects.com)

Latency Results – Fast Runs

Data Type	East	North	South	West
Avg. Position Latency (m)	-3.69	7.50	8.68	-5.28
Avg. GPS Speed (km/h)	227.9	237.9	234.4	235.1
Std. Deviation (m; km/h)	0.33; 4.96	0.13; 1.38	0.27; 2.54	0.67; 3.16

Latency Results – Slow Runs

Data Type	East	North	South	West
Avg. Position Latency (m)	-4.02	6.79	8.00	-4.83
Avg. GPS Speed (km/h)	204.1	212.1	208.9	210.3
Std. Deviation (m; km/h)	0.33; 6.17	0.26; 5.93	0.18; 2.91	0.26; 11.09

Ground Speed Calibration

Run	Elapsed Time (s)	S vs. T Area	GPS Ground Speed (km/h)	Cal. Gnd. Speed (km/h)	Error (%)
1	9.64	2200	228.18	227.92	-0.11
2	9.22	2198	238.35	238.30	-0.02
3	9.62	2199	228.61	228.40	-0.09
4	9.27	2199	237.17	237.02	-0.06
5	11.70	2198	187.87	187.79	-0.04
6	11.04	2198	199.12	199.02	-0.05
7	12.46	2197	176.32	176.34	0.01
8	12.49	2198	175.96	175.91	-0.03

Conclusions

- The SATLOC AirStar M-3 maintained a position latency of less than 9 m for a series of runs in the N, E, S, and W directions

- A positive latency was observed for N and S runs, but latency was negative for E and W runs.

Conclusions

- GPS ground speed data revealed highly accurate determinations with error ranging from 0.01% to 0.11% in magnitude.

- Consistently accurate and reliable performance of the photo-detector indicates that it is an effective approach for synchronizing aircraft position to positions on the ground.